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Ghana, Factor 3: Biofuels

The Implementation of MFC's Powered by Untreated Soil and Agricultural Waste in Rural Ghana

Bacteria can cause deadly disease, destroy environmental enterprises, and even harm entire ecosystems, but they may also hold the key to one of the largest issues facing our world today. Currently, Microbial fuel cells (MFCs) are being researched as a sustainable energy option. Pennsylvania State University, for example, is conducting studies on the efficiency of microbial fuel cells in wastewater treatment applications. According to Penn State's findings, MFCs have proven incredibly sustainable when applied to sanitation needs. Thus, MFCs have been successfully used in numerous sewage-treatment plants around the world, but can they prove a viable source of civil energy? Are they a great source of clean energy for all? Recent plans here in the US to incorporate the use of MFCs in large-scale municipal and industrial use seem to positively support the future of Microbial Fuel Cells.

Energy in Ghana, however available through the government and private corporations, is too expensive for utilization, at a cost between fifteen and forty-five Cedi (Ghanaian currency) per kilowatt hour depending upon the provider, and the geographical region. Though sixty-four percent of Ghanaians reportedly have "access" to electricity as of 2012 data collected by The World Bank, (seventy-four percent according to the United States Agency for International Development), the government regulates the prices, as well as the placement of powerlines found primarily in urban areas. In 2013, the Ghanaian Public Utilities and Regulatory Commission agreed to private energy company demands, to allow a raise in price by approximately one-hundred and fifty percent. To make matters worse, in February of 2015, *The Africa Report* published an article detailing the unreliability of electricity in Ghana, explaining the resulting physical and economic damage done to businesses and households throughout the nation (*Electricity: Ghana's power crisis deepens, 2015).* Furthermore, Ghana's main power plants run on fossil fuels, causing electricity to prove very expensive and economically out of reach for many of those living in Ghana. According to the "National Energy Statistics" produced by the Energy Commission of Ghana, demand for electricity reached an all-time high in 2015, a demand that was barely met primarily with dwindling carbon sources like oil and wood. If allowed to continue, energy production and consumption habits, such as the ones seen in Ghana, make many scientists worry about the impact on our planet and human health as more carbon dioxide and carbon monoxide are released into the atmosphere (as well as released in homes), and more carbon sinks are lost through deforestation. This fear was especially evident at the 2015 UN Climate Change Summit where world leaders, such as President Barak Obama, urged developing nations to "reduce their fossil fuel consumption." A slightly hypocritical request as most "developed" nations achieved their status on the back of coal and oil; these same, guilty "First and Second World" nations are now informing those who seek advancement that they will have to find another, more difficult, and more economically taxing way. Such requests have pressured the Ghanaian government to the point of passing the Renewable Energy Act 832. Electricity, specifically clean and reliable electricity, can aid in the proper preparation of food, reducing food borne illnesses, and can provide energy for pumping clean water for cooking and irrigation from deeper wells. Such access to energy, such energy independence, has the potential to improve the quality of life immensely, particularly for those in rural Ghana.

Conforming to environmental awareness, spurred on by Climate Change research and rhetoric, an Indian investor pact, Shri Kshetra Dharmasthala Rural Development Project (SKDRDP), grants rural communities and individual farms financial backing for electricity infrastructure like biogas tanks. These same constructions, already present on farms throughout India, Nepal, and Pakistan, can be utilized with slight modification as microbial fuel cells. SKDRDP has proven what a microfinance, non-government

organization is capable of accomplishing for rural communities, setting an example for similar funding in other nations. Right now, federal Ghanaian agencies, are empowered by parliament legislation, such as the "Energy Commission Act," with limited funds to improve rural access to power particularly with expensive solar panels. I hope to encourage further financial government investment in Ghanaian communities in addition to gaining private sector support similar to that of the SKDRDP through developing and producing cheap "MFC packets." "MFC packets" will contain electrical wires, materials, and directions for making charcloth and the proton exchange membrane. These can be sent or sold to rural and urban families to cleanly meet electricity needs.

Materials Needed for Single Cell MFC Construction:

4 Positive and Negative Thirty Inch Test Leads with Alligator Clip Ends

- One Gallon of Distilled Water
- Homemade Proton Exchange Membranes (PEM)
    - 10 grams of Salt (per fuel cell)
    - 5 grams of Gelatin (per fuel cell)
    - 200 ml of distilled water (per fuel cell)
- 4 Homemade Carbon cloths (charcloth)
    - 100% cotton cloth approximately 4 x 5 inches
    - 1 Metal Mint Container
    - Metal Window Screen, approximately 4 x 5 inches
- Duct tape

The above materials will build small fuel cells capable of producing enough electricity to perpetually power a small LED bulb. Once implemented, further research, maximizing electricity produced by native bacteria cultures would greatly benefit the endeavor. This research can easily be carried out in the field by those using the fuel cells. Also, continued investment
in technology able to function on smaller voltages will further aid the development and security of rural Ghana. To ultimately develop technology from phones to drones that are able to work longer on less energy can not only benefit those in rural, "developing" nations, but also has benefits on a global scale. Therefore, it should be an easy sell to any technology company looking to expand and grow their products.

Ghana has a growing population, increasing at a rate of approximately 1-3% per year. Their national age structure is extremely young, with 43% of the population under fifteen years old. This statistic can be majorly attributed to large families plus a relatively short life expectancy. The maximum age expectancy in Ghana today is around 63 (*General Information about Ghana, 2016*). This value, though having increased over the last few years further contributing to the rise in population, is significantly lower than the International life expectancy according to the World Health Organization. Those living in rural Ghana have an average of six children, while urban families have approximately four children. This brings the average immediate family size to around seven members. Because the population is so young, Ghana's workforce consists primarily of workers under twenty-five. As they are required to begin work in their youth, few Ghanaians have a formal education. Fifty-six percent of this labor force works in field agriculture on family farms. As the population increases, and as our world, alongside nations such as Ghana, becomes more technologically advanced, the need for energy increases. As people desire a higher quality of life; education opportunities, healthcare providers, and significantly, food security, are all heavily taxed, generating issues that can be resolved by reliable electricity.

The Ghanaian diet consists largely of rice, plantains, corn, cassava, yams, and beans. Agriculture in the nation produces many food crops, including some of their food staples such as corn, yams, and cassava. In addition, Ghanaians raise tomatoes, citrus fruits, pineapples, cashews, guavas, avocados, mangoes, bananas, and coconuts. However, they export the majority of this production and are only self-sustaining with plantain harvests (thus, ironically, the Ghanaian diet is anchored by imported produce). Ghana also

produces and exports palm oil, tobacco, sugar cane, and cotton. Finally, their rural economy includes enterprises that raise cattle, pigs, goat, sheep, chickens, and, through aquaculture, tilapia. Cotton and tomatoes are known as two valuable cash crops for Ghana with the cultivation of both providing the main source of income to many of Ghana's "peasant farmers." However, both of these crops require large amounts of irrigation that must be pumped from underground aquifers, as geographically, there is limited surface water in the regions of the nation responsible for cotton and tomato production. It is estimated by the World Wildlife Fund that, in order to produce a single T-Shirt and a pair of jeans, over 20,000 liters of water are required. Some form of energy, be it from humans, livestock, fossilized organic matter, or bacteria, is required for supplying this necessary resource to the fields.

The literacy rate in Ghana is 71.2%, ten percent below the international average (*World Data Bank, 2016*). This rate may be attributed to the 12,227 elementary schools in Ghana (approximately 1 for every 7.5 square miles). Though this statistic seems encouraging, limited secondary education possibilities discourage older minds with scarcely 474 high schools (about 1 for every 194 square miles), and only 66 universities for continued higher education (*CIA World Data Book*). Youth coming from rural families and communities have fewer opportunities to participate in higher education due to economic status, limited access to materials/facilities, and the lack of electricity preventing many simple tasks such as reading past sunset. Even adults searching for a career change in order to provide a better life for their family are restricted by these same adverse education factors. The schools themselves suffer from the unreliable electricity, making them costlier, incapable of providing an education that will allow participation and competition in the global economy, and ultimately preventing them from serving a larger number of students. As the world continues to grow technologically, relying more and more on energy dependent machines, any hope of joining our expanding international market is increasingly based on the opportunities accessible to students.

Like education, rural Ghana also has very limited access to modern medicine. They have to either rely on traditional medicine in their small villages, or the ill-equipped Health Posts/Health Centers they share with surrounding communities. Ghanaian doctors, or Medical Officers, are stretched incredibly thin with, as of 2013, approximately one trained Medical Officer for every nine-thousand seven-hundred citizens (Infrastructure and Resources, 2016). Such perseverant professionals attending these health posts, though trained in today's techniques, are forced to adapt to the primitive equipment due to lack of reliable electricity for patient care. Surgeons the United States interviewed a few of the Medical officers practicing in the larger hospitals located in the few Ghanaian metropolises. Their findings supported the conclusion documented in a 2011 report published by the *Academic Medicine: Journal of the Association of American Medical Colleges* iterating the slightly desperate needs of healthcare in Ghana. Prior to the 2000's, those with small incomes suffered underneath the "Cash and Carry" health care system, being denied treatment at Health Posts and hospitals without payment upfront. In the past few years, some government advances have been made, though healthcare infrastructure has not become accessible to all, even though the National Health Insurance Scheme has paved the way for affordable health care. The ability of each healthcare facility to cheaply meet their own individual energy needs with a clean, renewable, and reliable source will lower the economic burden shouldered by the patient as well as providing the

Cheap and simple, the design of a MFC, and the resulting availability of renewable energy will open new doors for families throughout Ghana. The immediate family benefits include an ability to study after dark and to cook indoors without the dangerous carbon monoxide/dioxide that is produced when fossil fuels or wood are burned. In addition, the electricity can be utilized for an animal husbandry practice (example: placing light in a henhouse to account for changing seasons in order to maintain laying rate), supporting a rural income and increasing community food security. Alongside these wonderful possibilities, reliable MFCs will help the overall community stay healthy at school, in the field, in the doctor's office, and at the dinner table.

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